Environmental Protection Agency

Sample Collection, Continuous Hydrocarbon Analysis and Particulate Collection of the Light Duty Diesel Test Procedure

This procedure is written for the Environmental Protection Agency, National Vehicle and Fuel Emissions Laboratory (NVFEL) internal use. The use of specific brand names by NVFEL in this procedure are for reference only and are not an endorsement of those products. This document may be used for guidance by other laboratories.

NVFEL Reference Number

713D

Implementation Approval

Original Procedure Authorized by EPCN #104 on 08-31-92

Revision Description

(1) 09-30-94 The purpose of this change is to revise the procedure as described in EPCN #170.

Table of Contents

Attachments

1. Purpose

The purpose of this procedure is to collect bag samples of hydrocarbon (HC), Carbon Monoxide (CO), Oxides of Nitrogen (NO_x), and Carbon Dioxide (CO_2) mass emission; to continuously analyze diesel hydrocarbon emission; and to collect particulate samples occurring during the urban dynamometer exhaust emission test and/or the highway fuel economy test.

The sample bag analysis procedure is detailed in TP 708, "Exhaust Sample Analysis."

Instructions for driving the Federal Test Procedure (FTP) and Highway Fuel Economy Test (HFET) schedules, including dyno hookup, stall, and no-start procedures, are in TP 707, "Sample Collection of the Urban Dynamometer Exhaust Emission Test," and TP 710, "Sample Collection of the Highway Fuel Economy Test."

Instructions for handling and weighing particulate samples are detailed in TP 714, "Diesel Particulate Filter Handling and Weighing."

2. Test Article Description

1981 and later model year light duty diesel-fueled certification and fuel economy data vehicles

3. References

3.1 "Code of Federal Regulations," Title 40, Subpart B, Sections 86.109, 86.110, 86.111, 86.112, 86.127, 86.135, 86.136, 86.137, 86.139, 86.140, and 86.142

3.2 "Beckman Model 402 Operating Manual"

3.3 "Continuous Hydrocarbon Analysis of Diesel Emission - SAE J215," SAE Recommended Practice, November 1970

3.4 Environmental Protection Agency (EPA) Reference Drawings and Schematics

3.5 TP 702, Vehicle Fuel Exchange

3.5.1 Gaseous Sampling System:

T0222B Schematic - Gaseous Sampling
T0220D Assembly Drawing - Gaseous Sampling System
T0189D Dilution Tunnel Assembly
T0210D Heated Sample Lines
T0211C RTD Adapter Fittings
T0221C Gas Temperature Probe Installation
T0209B Gas Temperature Probe
T0225B Beckman 402 Remote Module
T0226B Truth Table
T0227D Chassis & System Circuitry
T0228D Circuit Board Circuitry

3.5.2 Particulate Sampling System:

T0248C Particulate System Schematic

3.6 EPA Memo, David L. Schlotterbeck, October 11, 1977, “Procedures for Handling Diesel Particulate Matter”

3.7 EPA Equipment/Procedure Change Notice #019, “Change in Test Cell Humidity Specifications,” February 22, 1980

3.8 Calculator

3.9 EPA Test Procedures:

TP 707, “Sample Collection of the Urban Dynamometer Exhaust Emission Test”

TP 708, “Exhaust Sample Analysis”

TP 710, “Sample Collection of the Highway Fuel Economy Test”

4. Required Equipment

The analytical equipment listed below has been modified for EPA's use. Detailed schematics, diagrams, and photographs are kept at EPA-Ann Arbor and are available for public use.

No endorsement of specific equipment is implied by EPA's use. Other equipment may be used to produce equivalent results.

The equipment specified below is subject to change.

4.1 Horiba 1050 Critical Flow Venturi Constant Volume Sampling system (CFV CVS) with flow capacities of 350, 700, and 1050 cubic feet per minute (cfm):

4.1.1 Dilution tunnel, with dilution air filter

4.1.2 Heat exchanger unit

4.1.3 Constant Volume Sampler (CVS) pumps and blowers

4.1.4 CFV unit with 350, 700, and 1050 cfm capacity ventures

4.1.5 CFV CVS remote control bag selector switch, located on the driver's aid stand

4.1.6 Sample collection bags for background and exhaust emission samples

4.1.7 CVS control unit with elapsed time counters, blower off/on buttons, bag leak check system, V-mix counters, sample filter unit, flow range controls, pump on/off controls, pressure, temperature and flow output monitors, and a system schematics panel

4.2 Diesel hydrocarbon continuous analysis system:

4.2.1 Beckman Model 402 Heated Flame Ionization Detector (HFID) for measuring diesel hydrocarbons

4.2.2 HFID fuel, consisting of a blend of 40 ±2% hydrogen with a balance of helium and less than 1 part per million (ppm) Carbon (C) total hydrocarbons, and HFID air (hydrocarbon-free)

4.2.3 Span gases, which are blends of propane and hydrocarbon-free air.

The propane concentration of the span gas must be a minimum of 70% of full scale for the appropriate range.

4.2.4 Zero gas, consisting of hydrocarbon-free air (a blend of 20.9% 0_2 and 79.1% N_2)

4.2.5 HFID sample transport system

4.2.6 HFID control unit with HFID gas and wall temperature monitors, HFID output digital volt meter (DVM), elapsed time counters, 6-channel strip chart recorder with zero and span potentiometers, range selection buttons, oven and fluid bath temperature controls, and 2 Fluke multi-counters (referred to as “integrators”).

4.3 Particulate collection system:

4.3.1 Tri-filter assembly

4.3.2 Particulate pump

4.3.3 Particulate probe, located in the CVS dilution tunnel

4.3.4 Tylan mass flowmeter

4.3.5 Two dry gas meters

4.3.6 Particulate phase select system (filter to meter), with remote controls on the driver's aid and CVS control unit.

4.3.7 Particulate control unit with dry gas meters, Tylan flowmeter readout, dry gas meter and mass flowmeter temperature readouts, and a 6-channel strip chart recorder capable of measuring sample zone temperature, gas inlet temperature, wet and dry bulb temperatures, CFV CVS temperature, and particulate flow rate.

4.4 Bubble flowmeter to check the sample transport system for leaks, attached to the sample bypass flow on the HFID

4.5 Not more than 20 feet of smooth-wall stainless steel exhaust tubes covered with fiberglass insulation, measured from tailpipe to dilution tunnel.

This tubing shall have a maximum inside diameter of 4.0 inches.

Short sections of non-insulated flexible tubing at connection points are allowed.

4.6 Insulated leather gloves for handling hot exhaust equipment and changing heated filters

4.7 Disposable rubber or plastic gloves for handling equipment contaminated with diesel particulate matter

4.8 Tweezers for removing and replacing HFID filters

4.9 Waste container designated for disposal of filters, gloves, and any trash contaminated by diesel particulate matter

4.10 Dust protective face masks available for use when handling fiberglass covered exhaust tubing

4.11 Dynamometer verification unit for recording roll revs, inertia weight, and torque, located on the HFID control panel, with a remote control switch located on the driver's aid stand

4.12 Test cell ambient temperature monitoring system:

4.12.1 Type “J” or “T” thermocouple psychrometer or dew-point hygrometer

4.12.2 Wet and dry bulb temperature recorder

4.13 Form 703-02, “Diesel Vehicle Preconditioning,” (see TP 703)

Form 708-01, “Vehicle Test Data Sheet,” (see TP 708)

Form 713-01, “Diesel Sample Collection/ HFID Operation,” (Attachment A)

Form 713-02, “Diesel Sample Collection/Particulate Filter Handling,” (Attachment B)

Form 714-02, “Particulate Test Data Sheet,” (see TP 714)

Form 902-01, “Test Status Report”

5. Precautions

5.1 Operate diesel vehicles only when it is absolutely necessary and turn the engine off as soon as possible.

A diesel-fueled vehicle should not be driven within the laboratory building unless absolutely necessary.

If it is allowed to idle in the building for more than a few seconds, the vehicle must be connected to an exhaust vent.

5.2 When working with diesel particulate matter, skin contact must be prevented.

Technicians working on or with diesel emission test systems must use disposable rubber or plastic gloves, protective clothing, and dust masks as necessary to prevent contact with diesel particulate matter.

Tweezers and disposable gloves must be used for handling filters in an HFID, CFV CVS, or analysis bench which is used for diesel testing.

5.3 Gloves, protective clothing, and dust masks are considered used at the end of a single operation and must be disposed of in containers marked “DIESEL WASTE.”

When the container is full, the waste must be tied off and disposed of in containers designated by the Safety Officer.

5.4 Dust masks should be worn when handling the fiberglass exhaust insulation.

5.5 Eating is prohibited in any area where diesel testing takes place.

5.6 Insulated leather gloves must be worn as protection against burns when changing the heated diesel filters, working around the HFID oven, or handling hot exhaust pipes.

5.7 The area near the HFID must be free of liquids and flammable objects.

6. Visual Inspections

6.1 The HFID operator verifies that all documentation needed for the test is present.

6.2 The HFID operator briefly checks the wall and gas temperatures of the HFID before preparing for the test to verify that the HFID is operating properly.

6.3 All gas cylinder pressures are checked prior to test preparation to determine if there is enough gas to complete the test, usually around 500 pounds per square inch (psi).

6.4 Before the site is used for testing, all equipment is checked to ensure that calibration due dates are not exceeded.

7. Test Article Preparation

One senior technician is responsible for coordinating all activities in preparation for the test.

The areas of activity involving specific equipment are identified in the procedure as "Driver," "Bag Anal.," "Part.," "CVS," or "HFID."

Other technicians involved in performing these steps must coordinate them with the senior technician in charge of the test.

No equipment other than that specified in the procedure may be adjusted or used without first consulting with Calibration & Maintenance (C&M).

7.1 (Driver) Connect the vehicle exhaust system, leaving the tailpipe connection off until after the HC hang-up check (Step 7.15) has been performed.

Allow enough time and personnel to do this before the 2-hour dyno wait limit is exceeded.

Always wear disposable plastic gloves when handling diesel exhaust tubing and the fiberglass exhaust insulation.

Connections should be as short and straight as possible, with a minimum number of bends and use of flexible tubing.

Short pieces of flexible tubing (insulated or non-insulated) may be used at both ends of the rigid pipe to avoid stress on the exhaust flange.

The exhaust pipe should be insulated over its entire length. The length from tailpipe to dilution tunnel cannot exceed 20 feet (20 feet from the farthest tailpipe, in the case of dual exhaust vehicles).

Add up the total number of feet of exhaust pipe used and enter this on Form 714-02.

Also enter the exhaust configuration description data on this form (the number of elbows, if insulated, surface type, and tailpipe diameter).

7.2 Change the HFID filter. Turn off the "P2" pump on the HFID oven.

Wearing insulated gloves and using tweezers, remove the old filter from inside the oven, dispose of it in the special trash can marked for diesel waste only, and install a new filter.

Turn on the "P2" pump, located on the HFID oven.

Note: Opening the HFID oven causes the "Gas at Filter" temperature to drop. Allow enough time for the temperature to rise to specification before calibrating the HFID, usually about 5 minutes.

7.3 (CVS) Evacuate and purge the sample and background bags and leak check them.

7.3.1 Place the CVS control unit in the following configuration:

Test Select Mode: "OFF"

"REMOTE" mode selected

Flow range: 350 cfm for vehicles less than 3000 lb. inertia weight, 700 cfm for vehicles 3000 lb. inertia weight and greater, unless otherwise specified.

On Form 713-01, check the range used.

The technician may change the flow range for the highway fuel economy test for better accuracy.

Bag Purge - Select: "AUTO" and "ALL" (for all 6 bags) or select those bags which will be used for testing.

7.3.2 After the purge/evacuate cycle (approximately 2 minutes), turn the "AUTO" mode to "OFF" and push the "Leak Check" button.

7.3.3 If the leak check is good, the "LEAK CHECK" light will go off after approximately 1 minute.

Simultaneously monitor the pressure gauge at the bottom of the CVS control panel. The leak rate should be less than 1 inHg per minute.

7.3.4 If the leak check is bad, the "NO GO" light will activate. The leaking bag must then be located and replaced before the test can proceed.

7.4 (HFID) Leak check the HFID.

7.4.1 Place the HFID control panel in the "Leak Check" mode.

7.4.2 Attach the bubbler to the outlet of FL2 (bypass flowmeter). Observe the bubbler for 1 minute.

If the flow exceeds 15 cc/min., check for leaks, particularly around the heated filter. Notify C&M immediately if the leak cannot be stopped.

7.5 (CVS) Turn the CVS blower "ON."

7.6 (HFID) Flow check the HFID:

Start the HFID strip chart recorder (4 cm/min.)

Check and adjust the electrical zero on the strip chart, if needed.

Select the sampling range on the instrument multiplier.

Set the HFID to "SAMP." Adjust the flow rate reading on the HFID to 7 scfh.

Zero: Push the "ZERO" button on the HFID control panel.

If necessary, adjust the needle valve to match the flow rate obtained in the "SAMPLE" position.

Adjust the instrument zero potentiometer until an approximate zero chart reading is achieved.

Span: Push the appropriate range span button on the HFID control panel.

If necessary, adjust the needle valve to match the flow rate obtained in the "SAMPLE" mode.

Adjust the instrument gain potentiometer until an approximate span reading is achieved.

Zero: Push the "ZERO" button on the HFID control panel.

If needed, check and adjust the zero potentiometer until the chart reading is as close as possible to zero.

7.7 (HFID) Set the HFID to "SAMP" and check that the backpressure and flow rates are the same as those obtained in the beginning of the pre-calibration.

If they are not, notify the team leader.

7.8 (HFID) Monitor the gas and wall temperatures displayed on the HFID unit. These must remain within the posted tolerances during calibrations and during the test.

If out-of-tolerance conditions occur, do not attempt to adjust the temperature of the HFID, but notify C&M.

7.9 As each step is performed, it is checked off on Forms 713-01 and 713-02.

On Form 708-01, fill in the test date, driver and site operator IDs, dyno site (D007), actual inertia setting, IHp, odometer, and tire pressure.

7.10 (Part.) Leak check the particulate pump:

7.10.1 Go into the filter conditioning/weighing room and obtain the filter tri-assembly that has been loaded with conditioned filters (See TP 714).

On Form 713-02, record the temperature/humidity strip chart equipment tracking identification number, the time out of weighing chamber, and the date.

Do not connect the filter assembly to the probe until the test is ready to start (Step 7.19).

7.10.2 Turn off the particulate pump. Turn the CVS Test Select to the "OFF" position. Adjust the mechanical zero for particulate flow on the particulate strip chart.

7.10.3 Disconnect the quick-connect plug from the probe and install it into the input connection of the tri-filter assembly.

Attach the hoses to the output connections of the individual filters of the tri-filter.

Be sure to match the hose numbers to the output numbers.

7.10.4 Turn on the particulate pump.

Adjust the Tylan mass flowmeter to a flow rate within the range of 22.5 to 28 standard liters per minute (slm).

Calibrate the strip chart to match this reading.

7.10.5 On the CVS control panel, turn the Test Select to “Test 1.”

Monitor the particulate mass flowmeter (MFM) and dry gas meter (DGM) readings.

The MFM should fall to zero ±5 slm.

The DGM should indicate zero flow.

If flow is indicated either by the rotometer or dry gas meter, tighten the filter assembly and repeat the leak check.

If flow continues, close the ball valve at Solenoid Valve A, located near the dilution tunnel, which will aid in isolating the leak.

If Solenoid Valve A is leaking, notify C&M.

7.10.6 Return the CVS Test Select to “OFF.”

Turn off the particulate pump.

7.10.7 On Form 714-02, record the initial pre-test readings of Phase 1 and Phase 2 of the dry gas meters.

7.11 Stamp the strip chart with the appropriate stamp identifying the test number, date, operator ID, and the color coding for each channel.

7.12 (Driver) Start the ambient wet and dry bulb temperature chart at 1/2 inch per min. Allow the readings to stabilize.

Check the test cell temperature and humidity and adjust the reheat thermostat on the air handling unit if needed.

The dry bulb temperature should be 75 °F ±2 °F at the beginning of the test.

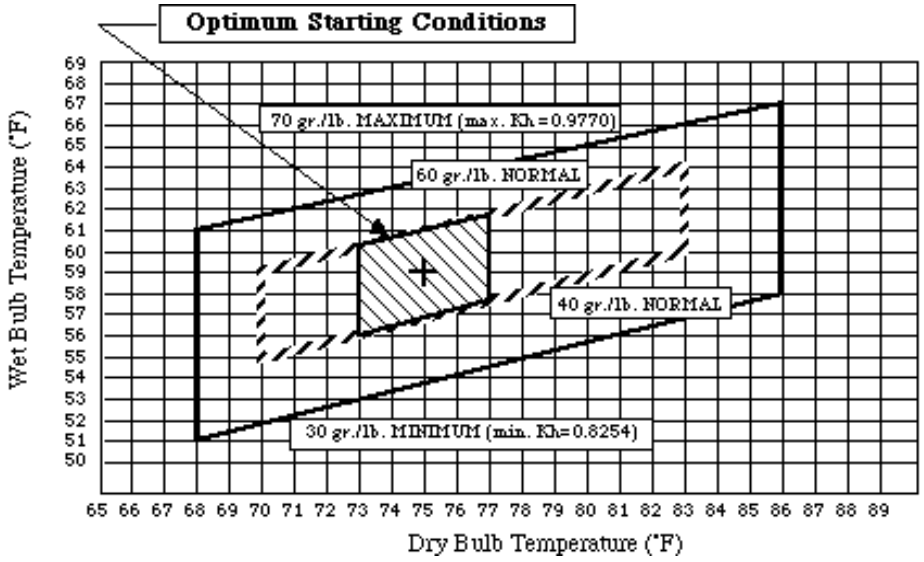
The wet bulb temperature may range between 56-62 °F, as long as it falls within the hatched area on the chart below.

If the test must be started when the temperature intersection is outside this area, but is within the broken-lined area, the test may proceed.

If the intersection between the average wet and dry bulb temperatures during the test falls outside the solid-line, the test will have to be voided.

Contact the supervisor so that corrective action can be initiated.

If the dry bulb temperature at any point during the test exceeds 86 °F or falls below 68 °F, the test is void.



7.13 (HFID) Calibrate the HFID.

Calibrations must be stable readings, set as close as possible but not more than ±0.4% of full scale from the calibration set point posted on the HFID control module.

A stable reading is 30 seconds of measurement (at 4 cm/min. or 1 in/min.) in which the variation is not more than 1.0% of full scale.

The numerical value of the reading is the operator's estimate of the average reading occurring during this 30-second period.

Zero: Place the CVS control panel in the “Local” and “Test 1” modes.

Push the “ZERO” button on the HFID control panel.

Adjust the zero potentiometer until a stable and accurate zero reading is achieved.

Check that the HFID backpressure and flow rates are the same as those obtained in the pre-calibration (Step 7.6).

Span: Push the appropriate range “SPAN” button on the HFID control panel.

Adjust the span potentiometer until a stable and accurate span reading is achieved.

Zero: Push the “ZERO” button on the HFID control panel, and check the zero reading.

If the zero repeats, the calibration is complete.

If the zero has shifted, adjust it and re-span and re-zero until there is no shift in the zero reading.

Mark off and identify all calibration areas and record the range number and span set point on the strip chart.

During the HFID calibration, check the Fluke frequency integrators for accuracy.

Place the following Fluke multi-counter control switches in the depressed position:

ATTEN
FILT
FREQ
1 Hz
POWER

While waiting for the first calibration zero to stabilize, select “Bag 1” on the CVS control panel. The first (left) multi-counter reading should agree within 1% of the strip chart and 0.5% of the DVM readings.

Select “Bag 2” on the CVS.

The second (right) multi-counter reading should agree within 1% of the strip chart and 0.5% of the DVM readings.

If the integrator readings disagree with the strip chart or DVM, immediately notify the senior technician.

Record the integrator output (e.g. “F = 0.01”) on the strip chart.

Return the CVS to the “REMOTE” mode.

Evacuate the sample and dilute air bags. Place the Fluke multi-counters in a test-ready condition by ensuring that the following buttons are pressed:

ATTEN
FILT
TOT
AUTO
POWER

It is the operator's responsibility to estimate this agreement among the integrator, strip chart, and DVM readings.

7.14 (HFID) Push the “Dilute Air” button on the HFID control unit and allow the reading to stabilize.

Mark this area “Dilute Air” on the strip chart.

7.15 (HFID) The vehicle exhaust must be disconnected from the CVS exhaust configuration and the CVS pump for this check.

Push the "SAMP" button on the HFID control unit and allow the reading to stabilize.

Monitor the HFID backpressure and flow rates as above. Mark this area "HC Hang-up" on the strip chart.

The hang-up reading should be no more than 0.5 ppm propane greater than the dilute air reading.

If it is greater, make a note of this on the "Comments" section of Form 708-01.

Leave the HFID in the "SAMP" position.

7.16 (Driver) Start the cooling fan(s).

7.17 (CVS) Turn on Soltec Recorder #2 and monitor the CFV-CVS temperature.

The set point at the start of the test should be 95 °F ±20 °F.

7.18 (Driver) Make the final vehicle exhaust connection.

7.19 (Part.) Attach the particulate filter assembly to the particulate probe. Verify that the particulate pump is on.

7.20 Verify that the HFID, CVS, and particulate control panels are in test-ready condition:

All counters are zeroed.
Both recorders are operating.
The CVS unit is "REMOTE" and "OFF;" the blower is "ON."
The HFID unit is on "SAMP."
All bags are evacuated.
All temperatures are within tolerance limits.

7.21 (CVS) As soon as the driver pushes the "Ready" button on the driver's aid, push "Rdy," "P1," and "P3" on the CVS unit.

8. Test Procedure

Five areas of responsibility are involved in the diesel test: the HFID unit, the CVS unit, the particulate unit, the bag analysis train, and the dynamometer/driving area.

Because of the length and complexity of this procedure, extreme efficiency is needed to avoid violating time limits.

The senior technician is responsible for coordinating the steps for these different areas.

This procedure is divided into two sequences. Sequence 100 is the urban dynamometer exhaust emission test (including particulate collection), and Sequence 200 is the fuel economy test.

In most cases, when problems occur the test should be continued to completion. The HFID operator should notify the supervisor in such cases.

100 Urban dynamometer exhaust emission test with particulate collection.

101 (HFID) As soon as the driver starts the car, note and record the clock time on Form 708-01. Mark the start point on the HFID and particulate traces.

102 Verify that the key start time minus the filter time out of weighing chamber is less than 1 hour. If it is not, notify supervisory personnel.

103 As the driver operates the vehicle for the first sampling period (also called “Bag 1” or “Phase 1”), monitor the HFID, CVS, and particulate control units as follows:

(HFID) Monitor the temperature outputs.

If any temperature exceeds the posted tolerance, notify the supervisor. Do not attempt to adjust the HFID temperature.

Monitor the integrator for overflow (indicated by a red light).

If the HC reading on the strip chart goes off-scale any time during the test, record the highest DVM reading on the chart.

Report any off-scale readings totaling more than 4 seconds to the supervisor.

(CVS) Monitor the temperature, pressure, and flow outputs on the CVS unit.

If these exceed the posted tolerances, notify the supervisor.

(Part.) Monitor the particulate control unit.

The particulate flow rate, as measured by the Tylan flowmeter, must be set to a point within the range of 20 to 30 slm and maintained within ±5% of the set point.

Adjust the control knob to maintain a constant flow rate.

Monitor the sample zone and dry gas meter temperatures, which must remain within the posted tolerances.

104 Immediately when the driver begins the second sampling period (Bag 2 or Phase 2):

(HFID) Mark the end of Sample 1 on the HFID and particulate strip charts.

On the HFID strip chart, record the elapsed time in seconds and the integrated output for Sample 1.

105 On Form 708-01, record the elapsed time in seconds and the V-mix from the CVS unit for each sample.

Zero the HFID elapsed time counter and HFID Integrator #1.

(Part.) Mark the end of Sample 1 on the particulate strip chart.

106 On Form 714-02, record the DGM reading and the average DGM temperature and pressure readings for Phase 1 (Bag 1).

107 (Bag Anal.) Analyze the first set of sample and background bags per TP 708.

108 Monitor the HFID, CVS, and particulate control units during the second sampling period (see Step 103).

109 Steps 109 through 122 must be completed during the 10-minute soak of the FTP.

Immediately when the driver completes the second sampling period:

(HFID) Mark the end of Sample 2 on the HFID and particulate strip charts.

Turn off the CVS blower and pumps (“RDY,” “P1,” and “P3”).

110 On the HFID strip chart, record the elapsed time in seconds and the integrated output for Sample 2. Zero the integrator.

111 On Form 708-01, record the elapsed time in seconds and the V-mix from the CVS unit for each sample.

112 Record the roll revolutions for Samples 1 and 2 from the dynamometer verification unit. Zero the counters.

(Part.) Mark the end of Sample 2 on the particulate strip chart.

113 On Form 714-02, record the DGM reading and the average DGM temperature and pressure readings for Phase 2 (Bag 2).

114 (Driver) Immediately after the vehicle is shut down, turn off the cooling fans and close the vehicle hood.

Monitor the test cell temperature during the 10-minute soak.

If the temperature falls below 72 °F, the reheat thermostat on the test cell air handling unit should be adjusted.

If corrective action fails, notify the team leader.

115 (HFID) Analyze Background Bag #1 for HC as follows:

Push “Bag 1” on the CVS unit and then push the “Bag” button on the HFID unit.

Obtain a stable reading (as defined in Step 7.13). Identify the bag and record the percent of full scale on the HFID chart.

116 (HFID) Analyze Background Bag #2 for HC per Step 115 above.

117 (Bag Anal.) Analyze the second set of background and sample bags per TP 708.

118 (HFID) Verify the calibration of the HFID. Verification span points must return to ±2.0% of full scale of the required set points and must be stable readings.

Span**:** Push the appropriate range “SPAN” button on the HFID control panel. Obtain a stable reading.

On the strip chart, identify the reading and record the required set point.

Zero: Push the “ZERO” button on the HFID control panel.

Obtain a stable reading and identify it on the strip chart.

If the verification is out-of-tolerance, the HFID must be calibrated, the bags must be analyzed, and the verification must be within the limits.

If the verification is still out-of-tolerance, notify the supervisor.

119 Calibrate the HFID for the third sampling period (see Step 7.13).

120 Allow dilute air to pass through the sample transport system by pushing “DILUTE AIR” on the HFID unit.

Mark this area “dilute air” on the HFID strip chart.

121 (HFID) After the dilute air reading stabilizes, turn the HFID unit to “SAMP” and check that all units are in a test-ready condition per Step 7.20.

122 (Driver) At 9 minutes into the 10-minute soak, notify the driver to turn on the cooling fan, open the vehicle hood, and prepare to drive the 3rd sampling cycle.

123 (CVS) Push the CVS pumps (“RDY,” “P1,” and “P3”).

This activates the driver's “Ready” light, indicating the test can begin.

123 (CVS, Part., HFID) As the driver operates the vehicle for the 3rd sampling period, monitor the HFID, CVS, and particulate units per Step 103.

124 As soon as the driver completes the 3rd sampling period (Bag 3 or Phase 3):

(HFID) Mark the end test point on the strip charts.

Turn off the CVS pumps.

Record the elapsed time in seconds and the integrated output for Sample 3 on the HFID strip chart.

(Part.) Mark the end-of-test point of the strip chart.

125 On Form 714-02, record the DGM reading and the average DGM temperature and pressure readings for Phase 3 (Bag 3).

126 Turn off the particulate pump.

127 On Form 714-02, record the maximum sample zone temperature.

128 Disconnect the tri-filter assembly and proceed with the particulate filter weighing and handling procedure, TP 714.

Record the time the filters were returned to the filter conditioning room on Form 713-02.

129 (Driver) Disconnect the exhaust connection tube from the vehicle.

130 (HFID) Analyze Background Bag 3 on the HFID (see Step 115).

131 (Bag Anal.) Analyze the background and sample bags per TP 708.

132 (HFID) Verify the calibration of the HFID (Step 118).

Take a dilute air reading and perform an HC hang-up check after the vehicle exhaust connection tube has been disconnected from the vehicle (Steps 7.14 and 7.15).

133 (CVS) Record the roll revs and the elapsed time from the CVS unit and the V-mix for the 3rd set of bags on Form 708-01.

134 (Driver) Obtain the test cell temperature chart. Verify that the temperature limits of 68-86 °F were maintained during the test.

Average the test cell temperature and record it on Form 708-01.

135 (Driver) Observe the barometer reading in the test cell and record it on Form 708-01.

136 (HFID) On Form 708-01, record the integrated output and duration of sampling time for each sampling period.

Using a calculator, compute the average deflections for each sample by dividing the integrated HFID output by the duration of sampling time in seconds.

Record the calculated data on Form 708-01.

Obtain the gaseous emission results from the bag analyzer and transfer them to Form 708-01.

137 (HFID, Part.) Validate the HFID and particulate strip charts to verify that readings are properly identified, calibrations are correct, and temperature tolerances are not exceeded.

138 Validate the driver's trace for adherence to tolerance limits.

139 Evacuate, purge, and leak-check the sample bags per Step 7.3.

140 Place the testing site in a standby or end-of-day mode, as appropriate:

Standby - Allow dilute air to pass through the sample transport system and turn the chart recorders to “Standby” if the system is to be used again during the testing day.

Leave the CVS blowers on and the HFID in the “SAMP” mode.

End-of-day - At the end of the testing day, place the system in the following mode:

CVS unit - blower “OFF,” “Test Select” off, “LOCAL” mode.

HFID unit - “SAMPLE” mode, sample pump “P2” off.

Particulate unit - Pump off; quick-connect plug attached to probe; filter hoses connected to hose holder.

Strip chart recorders - Pens up and capped; chart speed at zero.

200 Fuel Economy Test:

If the test vehicle is scheduled only for a fuel economy test, all steps in Section 7 must first be performed.

If the fuel economy test is scheduled back-to-back with the exhaust emission test (Sequence 100) perform preparation Steps 7.2, 7.3, 7.4, 7.9, 7.11, 7.12, 7.13, 7.14, 7.15, 7.17, 7.18, and 7.20.

201 (CVS) Before the driver begins the warm-up cycle, start the CVS blower.

202 (Driver) Before starting the warm-up cycle, turn on the cooling fans and the test cell temperature recorder and open the hood of the vehicle.

Detailed instructions for preparing the test cell for the fuel economy test are outlined in TP 710.

203 As soon as the driver begins the warm-up fuel economy cycle, note and record the clock time on Form 708-01.

204 Monitor the HFID gas and wall temperatures.

If any should exceed the given tolerance, notify the supervisor.

205 During the warm-up cycle, turn on the HFID and particulate strip charts.

206 When the driver signals “Ready” just before the start of the measurement cycle, turn on the CVS pumps (“RDY,” “P1,” and “P3”).

Mark the start point on the HFID and particulate traces.

207 As the driver operates the vehicle for the sampling period, monitor the HFID, CVS, and particulate control units as follows:

(HFID) Monitor the temperature outputs.

If any temperature exceeds the posted tolerance, notify the supervisor and contact C&M.

Monitor the integrator for overflow (indicated by a red light).

If the HC reading goes off-scale at any time during the test, record the highest DVM reading on the chart.

Report any off-scale readings totaling more than 4 seconds to the supervisor.

(CVS) Monitor the temperature, pressure, and flow outputs on the CVS unit.

If these exceed the posted tolerances, notify the supervisor.

(Part.) Monitor the strip chart on the particulate control unit for adherence to CVS and ambient cell temperature tolerances.

208 Immediately when the driver completes the sampling period:

Mark the end-of-test point on the HFID strip chart.

Record the elapsed time in seconds of HFID sampling and the integrated output on the HFID strip chart.

Zero the elapsed time counter and integrator.

209 (CVS) On Form 708-01, record the V-mix counts and elapsed time in seconds from the HFID control unit and the roll revolutions from the dynamometer verification unit.

210 Analyze the background bag:

Push "Bag 1" on the CVS unit and then push the "Bag" button on the HFID unit.

Obtain a stable reading. Identify the background reading on the HFID chart.

211 (Bag Anal.) Analyze the background and sample bags per TP 708.

212 As soon as the driver turns off the vehicle engine, turn off the CVS pumps and blower.

If a quick check coastdown procedure is being performed, wait until it is completed.

213 Verify the calibration of the HFID. Verification span points must return to ±2.0% of full scale of the required set points and must be stable readings.

Span: Place the CVS control panel in the "Local" and "Test 1" modes. Push the appropriate range "SPAN" button on the HFID control panel.

Obtain a stable reading. On the strip chart, identify the reading and record the required set point.

Zero: Push the "ZERO" button on the HFID control panel. Obtain a stable reading and identify it on the strip chart.

If the verification is out-of-tolerance, notify the Vehicle Testing (VT) supervisor.

214 Take a dilute air reading and perform an HC hang-up check after the vehicle exhaust connection tube has been disconnected from the vehicle (Steps 7.14 and 7.15).

215 (Driver) Obtain the test cell temperature chart. Verify that the temperature limits of 68-86 °F were maintained during the test.

Average the test cell temperature and record it on Form 708-01.

216 (Driver) Observe the barometer reading in the test cell and record it on Form 708-01.

217 Using a calculator, compute the average deflections for the sample by dividing the integrated HFID output by the duration of sampling time in seconds.

Record the calculated data on Form 708-01.

Obtain the bag analysis data and transfer it to Form 708-01.

218 Validate the HFID and particulate strip charts to verify that readings were properly identified, calibrations were correct, and temperature tolerances were not exceeded.

219 Validate the driver's trace for adherence to tolerance limits.

220 Evacuate, leak check, and purge the sample bags per Step 7.3.

221 Place the HFID in a standby or end-of-test mode, as appropriate:

Standby - Allow dilute air to pass through the sample transport system and turn the chart recorders to “Standby,” if the system is to be used again during the testing day.

Leave the CVS blowers on and the HFID in the “SAMP” mode.

At the end of the testing day, place the system in the following mode:

CVS unit - blower off; “Test Select” off; “LOCAL” mode.

HFID unit - “SAMPLE” mode; Sample Pump P2 off.

Particulate unit - Pump off; quick-connect plug attached to the probe; filter hoses connected to the hose holder.

Strip chart recorders - Pens up and capped; chart speed to zero.

9. Data Input

9.1 The following data are recorded on Form 708-01.

9.1.1 On Line C, record the test date, driver ID, site operator ID, dyno site, actual inertia setting, indicated dyno Hp, odometer reading, tire pressure, barometer reading, wet and dry bulb average temperatures, and CVS inlet pressure.

9.1.2 On Lines D, E, and F, as applicable, record the CVS site number, dynamometer roll revolutions, and CVS V-mix counts are recorded for each sample.

Also, record the background and exhaust readings with the range numbers for HC, NO_x, CO_2, and CO obtained from the analysis site operator.

9.1.3 On Line G, record the HFID background measurement and calculated HFID output for each sample (computed in Step 136 or 217).

9.1.4 On Line H, record the HFID site number.

9.1.5 On Lines J, K, and L, record the integrated output and duration of sampling time for each sampling period.

Also, note any peculiarities that occurred during sampling, such as HFID strip chart over range.

9.2 On the HFID strip chart, record the test number, date, vehicle manufacturer, vehicle ID number, chart speed, strip chart recorder equipment tracking ID number, and the operator's identification number.

The HFID chart is stamped to identify the color coding of each channel.

9.2.1 At the end of each sampling period, the duration of HFID sampling in seconds and the integrated HFID output are recorded.

9.2.2 The deflection reading for each background measurement is recorded on the strip chart.

9.3 On the particulate and test cell ambient conditions strip chart, record the test number, date, vehicle ID number, chart speed, strip chart recorder equipment tracking ID number, operator ID, and chart speed.

The particulate chart is stamped to identify the color coding of each channel.

Note: These data are needed for both the FTP and HFET.

9.4 On the test cell temperature chart, record the date, vehicle ID number, chart speed, strip chart recorder ID number, test starting and ending points, and the test number.

9.5 Forms 713-01 and 713-02 are completed as each step is performed.

9.6 Data are recorded on the driver's trace according to instructions provided in TP 707 or 710, as applicable.

9.7 The following information is recorded on Form 714-02 for particulate tests only:

9.7.1 Pre- and post-test dry gas meter readings for Phases 1, 2, and 3

9.7.2 Dry gas meter temperature readings (average) for Phases 1, 2, and 3

9.7.3 Dry gas meter pressure readings (average) for Phases 1, 2, and 3

9.7.4 Maximum sample zone temperature during the test

9.7.5 Test filter numbers

9.7.6 Exhaust configuration data

9.7.7 Test, vehicle, and operator identification data

10. Data Analysis

10.1 The driver's trace and temperature strip chart are given to the senior technician after the test.

10.2 The HFID and particulate strip chart traces are collected by the senior technician.

10.3 The bag analysis data are given to the senior technician, who then transfers it to Form 708-01.

The bag analysis strip chart and worksheet accompany the form.

10.4 Forms 713-01, 713-02, and 714-02 are reviewed for completeness and accuracy by an independent technician upon completion of the emission testing sequence. He/she signs and dates the forms, as required.

11. Data Output

11.1 All forms and test records are verified by a qualified technician who did not record the data. The technician checks the data for completeness, accuracy, and compliance with EPA regulations.

He/she will write his/her identification number and date in the "Verified By" area of the forms.

On the strip chart, the technician will write his/her identification number and "OK."

This certifies that the data are accurate and complete.

11.1.1 All calibrations were properly made and identified.

11.1.2 All verifications remained within quality control tolerances.

11.1.3 All measurement areas were correctly identified.

11.1.4 The calculated HFID output was higher than the hydrocarbon measurements taken from the sample bags analyzed by the cold FID.

11.1.5 The correct test number, date, and operator ID appear on the strip chart, along with the color coding stamp.

11.1.6 All temperature tolerances for the HFID were met.

Any of these limits which cannot be verified or are not within tolerance should be entered in the "Comments" section of Form 708-01.

11.2 The driver reviews the ambient temperatures (wet and dry bulb) to verify that temperature tolerances were met.

11.3 The senior technician reviews the particulate strip chart to verify that the CVS temperature remained within tolerance.

11.4 The senior technician reviews the particulate strip chart to verify that the particulate flow rate and sample zone temperature remained within tolerance.

11.5 The HFID operator reviews the dynamometer roll revolutions to verify adherence to quality control tolerances. Roll revolutions which were out-of-tolerance are reviewed on a case-by-case basis before the raw data are submitted to Data Control.

11.6 Quality Control flags generated in data reduction are investigated by Data Control to ensure that raw data were accurately reported and correctly entered into the computer.

If an investigation reveals incorrect raw data or inaccurate computer entries, Data Control will coordinate corrective action with Vehicle Testing.

If corrected data can be obtained, the data may be reprocessed.

If corrected data are not available, the test should be voided.

11.6.1 Hydrocarbon background concentrations greater than 7.5 ppm C are flagged in data reduction.

11.6.2 Barometer readings less than 28.4 inHg or greater than 29.6 inHg are flagged in data reduction.

11.6.3 Humidity (NO_X) correction factors less than 0.86 or greater than 0.94 are flagged in data reduction.

11.6.4 Dynamometer roll revolutions which are not within quality control tolerances are flagged in data reduction.

11.6.5 HFID strip chart off scale readings are flagged in data reduction.

12. Acceptance Criteria

If acceptance criteria are not met, the test must be voided.

12.1 The ambient dry bulb temperature in the test cell must remain within 68-86 °F at all times when the test vehicle is in the test cell.

12.2 The average test cell humidity during the test must be between 30 and 70 grains per pound.

12.3 All analyzer calibrations must be accurate to within ±0.4% of full scale of the required span point.

All verifications must be accurate to ±2.0% of full scale of the required span point.

12.4 The CFV-CVS temperature must remain within ±20 °F of the designed operating temperature during the test.

12.5 The monitored HFID wall temperatures must remain 191° ±11 °C during the test.

12.6 The monitored HFID gas temperatures must remain 191°±6 °C during the test.

12.7 The particulate flow rate must remain at the set point ±5% during the test.

12.8 The particulate sample zone temperature may not exceed 52 °C during the test.

13. Quality Provisions

These are in-house tolerances and checks made to ensure the integrity of results. When violated, they do not necessarily require that a test be voided.

13.1 The HFID leak rate may not exceed 15 cc per minute.

13.2 The particulate leak rate may not exceed 0.5 slm.

13.3 The HC hang up may not exceed the dilute air reading by more than 0.5 ppm.

13.4 The Fluke integrators, HC strip chart, and DVM readings must agree with each other within 2%.

13.5 Dry/wet bulb temperature specifications must be within the hatched area on the chart from Step 7.12 before the test may begin.

13.6 The HFID may not be off scale for more than 4 seconds total during the test.

13.7 The technician follows the sequence of steps on Forms 703-02, 713-01, and 713-02, recording data as needed.

13.8 The technician's identification number must appear on all forms and test records, certifying that the data are accurate and complete.

13.9 Variations from the procedure are documented on Form 903-01.

Attachment A

Diesel Sample Collection / HFID Operation

Vehicle ID#: _____ Test Number: _____

HFID/CVS Set-up

1. Change HFID filter.
2. Check the CVS range used: _____41A _____41C
3. Perform CVS bag and HFID leak-checks.
4. Pre-calibrate HFID; adjust flow rates to 7 scfh.
5. Check that HFID gas & wall temperatures are in specification
6. Calibrate HFID just before start of test.
7. Measure Dilute Air and HC Hang-up.

HFID Emission Test

1. Monitor HFID gas & wall temperatures and CVS temperature at all times during test.
2. Record elapsed time and integrated output on strip chart at the end of each bag.
3. Analyze background samples on the HFID for each bag.
4. Verify all analyzer calibrations at end of bags 2.
5. Calibrate HFID and measure dilute air and HC hang-up before start of bag 3.
6. Verify all analyzer calibrations at end of bags 3.

Signatures

I have performed all steps in accordance with the requirements of Test Procedure 713 and 714.

Technician ID #: _____ Date: _____

The data entries are correct and meet the requirements of Test Procedure 713 and 714.

Verified by: _____ Date: _____

Attachment B

Diesel Sample Collection / Particulate Filter Handling

Vehicle ID#: _____ Test Number: _____

Particulate System Set-up

1. Ensure filters are properly conditioned prior to testing.
2. Weigh pre-test filters.
3. Load filter tri-assembly with conditioned filters.

   Record Strip Chart Recorder ET Number: _____

   Record time filters out of weighing chamber: _____ Date: _____
4. Leak-check the particulate pump.
5. Record the initial DGM readings on Form 714-02.
6. Just before the start of the test, attach the tri-filter assembly to the probe.
7. When the vehicle is started, record the Test Key Start time on Form 708-01.
8. Verify that the Test Key Start Time minus the time out of weighing chamber is less than 1 hr.

Particulate Emission Test

1. Verify that the Tylan flow maintained +5% from set point during each bag.
2. At the end of each bag, record the DGM reading on Form 714-02.
3. At end of test, remove filter assembly and condition post-test filters in the weighing chamber.
4. Record the time filters returned to weighing chamber: _____

Signatures

I have performed all steps in accordance with the requirements of Test Procedure 713 and 714.

Technician ID #: _____ Date: _____

The data entries are accurate and meet the requirements of Test Procedure 713 and 714.

Verified by: _____ Date: _____